# Ambient Hydrogen Sulphide, Total Reduced Sulphur Compounds and Sulphur Dioxide Levels inthe Vicinity of Manitoba Forestry Resources Ltd., The Pas, Manitoba. 1983

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## ABSTRACT

At the request of the Air Pollution Control Section of Environmental Control Services, operators of the Mobile Monitoring Unit carried out a study to determine ambient ground level concentrations of hydrogen sulphide, total reduced sulphur (TRS) compounds, and sulphur dioxide in the environs of the Manitoba Forestry Resources, Ltd. pulp and paper mill, in the Town of The Pas, Manitoba during June 1983.

Results from the study indicate that ambient hydrogen sulphide and TRS levels during certain meteorological conditions could periodically exceed Manitoba Air Quality Guidelines. Ambient sulphur dioxide was within objective levels during the air monitoring survey. Also during the monitoring project, noise levels were monitored, and levels were found to be within existing guidelines.

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## 1. BACKGROUND

Manitoba Forestry Resources Ltd. (MANFOR), formerly privately owned and called Churchill Forest Products Ltd., has operated a kraft pulp and paper mill in The Pas, Manitoba since the early 1970's. This crown corporation is a producer of unbleached pulp from predominantly black spruce logs. Current production is approximately 400 tonnes per day of air dried pulp.

Kraft (sulphate) pulping is accomplished by heating wood chips under pressure in an aqueous solution of pulping chemicals. Extensive recovery and recycling of these pulping chemicals is conducted.

Several steps in the pulping and chemical recovery operations may contribute to the production of significant quantities of emissions into the atmosphere.[1] Air pollutants are typically gaseous and particulate and orginate from the following sources in the mill:

a) digester system
b) multiple effect evaporator system
c) lime kiln
d) smelt dissolving tank
e) recovery furnace system.

The characteristic odour of a kraft pulp mill is principally due to the presence of (total) reduced sulphur (TRS) compounds. Included in these compounds are; i) hydrogen sulphide - $H_2S$, ii) methyl mercaptan - $CH_3SH$, iii) methyl sulphide $(CH_3)_2S$ and dimethyl disulphide $(CH_3)_2S_2$. These TRS compounds are extremely odourous even at very low concentrations. Typical odour thresholds have been reported.[2]

| | |
|---|---|
| Hydrogen sulphide | .00047 - .0047 ppm* |
| Methyl mercaptan | .002 ppm* |
| Dimethyl sulphide | .001 ppm* |

While ground level concentrations as a result of gaseous emissions from the kraft pulp mill are usually not significantly detrimental to human health, they do represent a significant nuisance to the local population because of their unpleasant odour. Several citizen complaints from The Pas area confirms this.

Several studies have been undertaken (or are underway) to investigate the mill emissions and their potential effect on air quality.

Ambient air quality monitoring began in October, 1973, and was implemented by the Environmental Management Division at a site located in the The Pas Provincial Building, 3rd Street West and Ross. This stationary permanent monitoring site, located about 4.8 km southwest of the Manfor Mill, measures total reduced sulphur compounds, reported as $H_2S$, utilizing a Philips PW 9700 (modified) coulometric analyzer. Monitoring to date has been continuous.[3]

Two stack sampling surveys of emission levels from the Manfor Mill have also been performed. Stack sampling for sulphides in 1974 established TRS emissions ranging from 5,189 to 43,262 ppm.[4] A second survey[5] for particulate emissions was undertaken concurrent to the ambient survey reported in this study.

At the request of the Air Pollution Control Section of Environmental Control Services and in order to provide more information on ambient air quality, especially within the impingement

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* ppm - part per million by volume

areas of the Manfor plume, a study was undertaken utilizing the Mobile Monitoring Unit downwind of the pulp mill June 14-17, 1983. Sampling was performed during these days as meteorological conditions permitted identification of accessible exposed areas.

Specific objectives of this study were:

1. To determine ambient ground level concentrations of hydrogen sulphide, total reduced sulphurs and sulphur dioxide in the vicinity of the mill.
2. To compare concentration levels to Manitoba Ambient Air Quality Objectives/Guidelines.
3. To determine geographic areas where potentially elevated levels might occur.
4. To measure sound levels at several sites in the vicinity of the plant for comparison with Manitoba sound level objectives.

The following sections summarize applicable air quality objectives, the sampling and monitoring procedures used, the results, and a discussion of concentrations found.

## 2. MANITOBA AIR QUALITY OBJECTIVES AND GUIDELINES

Manitoba Air Quality Objectives and Guidelines have been formulated for various air pollutants. The objectives for sulphur dioxide and hydrogen sulphide (see Table 1) have been adopted from the National Ambient Air Quality Objectives (hydrogen sulphide levels are currently only proposals). The Provincial criteria have been established for two levels:

Maximum Acceptable Level (MAL) - This level is intended to provide adequate protection against effects on soil, water, vegetation, materials, animals, visibility, personal comfort and well being.

Maximum Desirable Level (MDL) - This level defines long term goals for air quality and provides a basis for an anti-degradation policy for the unpolluted parts of the Province and for the continuing development of control technology.

## 2.1 Hydrogen Sulphide

The rationale for the choice of concentrations for this parameter relates primarily to the control of annoyance due to odours and effects on materials. As cited, the odour threshold for hydrogen sulphide has been reported in the range of .65 to 6.5 micrograms per cubic meter of air (.00047-.0047 ppm).[2 & 6] Above this range, the gas is perceived distinctly by its characteristic odour of rotten eggs.

Material effects include paint discolouration (especially lead-based paints) and the tarnishing of silver and copper (reported at a concentration of 4$\mu g/m^3$ after 40 hours).

The minimization of both the odour annoyance and material effects have been considered in the selection of the maximum acceptable concentrations which also are considered to be realistic and achievable in an industrial context.

## 2.2. Sulphur Dioxide

Background levels of sulphur dioxide in the atmosphere are 4 micrograms per cubic metre ($\mu g/m^3$) or less and there is no evidence that these levels can cause harm to the environment.[7] Levels well in excess of the background concentration can, however, have a deleterious effect on vegetation and human health.

The maximum acceptable levels have been designed on the basis of the following considerations:

Levels of less than 900 $\mu g/m^3$ (0.34 ppm) average for 1 hour will help prevent discomfort to sensitive individuals, with respect to

taste and odour, and will prevent the persistence of concentrations of $SO_2$ for several hours which have the potential to injure vegetation.

Levels of less than 300 $\mu g/m^3$ (0.11 ppm) average for 24 hours in conjunction with low suspended particulate matter in air will help to prevent health effects.

Levels of less than 60 $\mu g/m^3$ (0.02 ppm) average for 1 year will minimize the occurrence of chronic effects in forests.

The maximum desirable levels have been justified on the basis of being at or below the threshold of very slight human health effects and very slight chronic effects to forests.

### 2.3 Total Reduced Sulphur Compounds

Neither objectives nor guidelines have been formulated to specifically address total reduced sulphur levels. However, since these compounds are very odourous at low concentrations, similar to $H_2S$, the guidelines for hydrogen sulphide are considered to apply.

## 3. PROCEDURES

### 3.1 Sulphur Dioxide ($SO_2$)

Monitoring for sulphur dioxide was performed using a Thermo Electron Model 43 pulsed fluorescence ambient $SO_2$ analyzer. Pulsating ultraviolet light is focused through a narrow bandpass filter into a fluorescence chamber. Sulphur dioxide molecules are excited to a higher energy state in the chamber and then give off a decay radiation (light) characteristic for $SO_2$. This radiation is allowed to pass selectively through a second filter to impinge on a photomultiplier tube. The light emissions are processed electronically, such that the light energy is converted into a voltage signal which is proportional to the concentration of sulphur dioxide in the sample being analyzed. This method is highly specific, with few interferences.

TABLE 1. Ambient Air Quality Criteria

| CONTAMINANT | AVERAGING PERIOD | MAX. DESIRABLE LEVEL (MDL) | MAX. ACCEPTABLE LEVEL (MAL) |
|---|---|---|---|
| Hydrogen Sulphide | 1-hour | - | 15 (0.011) |
| | 24-hour | | 5 (0.004) |
| Sulphur Dioxide | 1-hour | 450 (0.17) | 900 (0.34) |
| | 24-hour | 150 (0.06) | 300 (0.11) |
| | Annual | 30 (0.01) | 60 (0.02) |

Concentrations are expressed in units of micrograms of contaminant per cubic meter ($\mu g/m^3$) of air corrected to standard conditions of 25°C and 101.3 kilopascals of pressure. The part per million - ppm - (by volume) equivalent concentrations are given in parentheses.

3.2 Hydrogen Sulphide ($H_2S$)

Analysis for hydrogen sulphide in ambient air was measured using a TGM 555 automated colorimetric analyzer, with hydrogen sulphide module installed. This instrument uses a modified form of the methylene blue method for hydrogen sulphide described in the NIOSH (National Institute for Occupational Safety and Health) Manual for Analytical Methods (Vol. 2, Method S4). Hydrogen sulphide in ambient air is collected by reacting it with an alkaline suspension of cadmium hydroxide, to form cadmium sulphide. The amount of sulphide collected is determined by the spectrophotometric measurement of the methylene blue produced by the reaction of the sulphide with an acid solution of N,N-dimethyl-p-phenylenediamine and ferric chloride. This method is specific for hydrogen sulphide with few interferences.

3.3 Total Reduced Sulphur (TRS)

The Philips $H_2S$ analyzer (Model 9700 - modified) was used to measure total reduced sulphur compounds. The instrument was operated with an on-line heated filter and sulphur dioxide scrubber.

Ambient air is drawn through an acidic aqueous bromine solution. The TRS compounds react with bromine in the measuring cell to produce ions which then react reversibly to release electrons. The number of electrons released and subsequently detected (per unit time) by a measuring electrode is proportional to the mass of TRS compounds entering the analyzer.

The analyzer was calibrated daily through the use of its internal $H_2S$ source. Ambient TRS concentrations were reported in units relative to this $H_2S$ calibration. Typical response by the Philips analyzer to TRS compounds have been identified[8] as:

| | | |
|---|---|---|
| 1. | Hydrogen sulphide | 100% (of actual) |
| 2. | Methyl mercaptan | 100% (relative to $H_2S$) |
| 3. | Dimethyl sulphide | 50% (relative to $H_2S$) |
| 4. | Dimethyl disulphide | 300% (relative to $H_2S$) |

3.4 Sound Monitoring

Sound level measurements were made utlizing a hand-held Bruel and Kjaer Model 2205 sound level meter. Measurements were made with the response setting on "Slow" and the monitor in "A" weighting, audible frequency range for humans. Readings were obtained from the meter and recorded. Other pertinent information, such as weather conditions, wind speed and direction, and calibration readings (monitor was calibrated for each test using a 94 dBA, 1000 hz tone generator), was recorded in a log book. Sound levels were monitored at each site over a 15-30 minute period to obtain representative levels.

3.5 Wind Speed and Direction

Wind speed and direction were obtained from an on-board meteorological tower. The tower, with a Windflo 540 wind speed and direction sensing instrument, manufactured by the Athabasca Research Corporation Ltd., was raised to a 10 metre height. Wind speeds (although not recorded on the accompanying table) were recorded on strip charts during the monitoring program. The output from the anemometer is a voltage and was converted to the appropriate engineering units (i.e. km/hr). The same principle applied to the wind direction. Directions given are relative to True North taking into account the magnetic declination which is approximatly $15^{\circ}$ 21' east in the vicinity of The Pas.

## 4. MONITORING SITES

Ambient air monitoring was conducted at a total of three sites during the three days of sampling for the Manfor project. Two of

these sites were directly south of the mill at a distance of approximately 2.8 km. The third site was located approximately 12 km northeast of the mill.

Sound level measurements were taken at five different sites, intermittently, during the same time period.

A detailed description of the location for each site accompanies Map 1[9] in Appendix A.

## 5. RESULTS

Hourly averaged and peak concentrations* of hydrogen sulphide, total reduced sulphurs and sulphur dioxide measured at each site for the time duration of sampling are shown in Table 2. Corresponding wind directions measured on-site and operator general comments are also shown.

Hourly averages were calculated using 12 - 5 minute average concentrations obtained by visual averaging of the strip chart records from the various analyzers.

A summary of sampling duration and average concentrations of hydrogen sulphide and total reduced sulphurs for each site is shown in Table 3. The survey data is further summarized for a comparison of downwind versus background levels in Table 4.

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* Peak concentrations are given for informative reasons only. Comparing peak level with respect to average concentrations can give an idea of the variability of readings during that period.

TABLE 2 - Monitoring Results

Hanford Study, The Pas, Manitoba - June 14-17, 1983

| Time (Hours) | Site No | $H_2S$ conc.(ppm) 1 hr.TWA | $H_2S$ conc.(ppm) Peak | TRS conc.(ppm) 1 hr.TWA | TRS conc.(ppm) Peak | $SO_2$ conc.(ppm) 1 hr.TWA | $SO_2$ conc.(ppm) Peak | Wind | Comments |
|---|---|---|---|---|---|---|---|---|---|
| June 14 | 1 | | | | | | | | |
| 11:00-12:00 | | - | - | .012* | .037 | <.01 | <.01 | 320° | -cloudy, strong odour, visible haze (photos available) |
| 12:00-13:00 | | .006 | .013 | .009 | .022 | <.01 | <.01 | | -intermittent precipitation |
| 13:00-14:00 | | .009 | .028 | .009 | .048 | <.01 | <.01 | | |
| 14:00-15:00 | | .002 | .003 | <.004 | <.004 | <.01 | <.01 | 350° | -faint odour |
| 15:00-16:00 | | .003 | .008 | cal. | cal. | cal. | cal. | | |
| 16:00-17:00 | | .003 | .005 | <.004 | <.004 | <.01 | <.01 | | |
| 17:00-18:00 | | - | - | <.004 | <.004 | <.01 | <.01 | | |
| 18:00-19:00 | | - | - | <.004 | <.004 | <.01 | <.01 | | |
| 19:00-20:00 | | - | - | <.004 | <.004 | <.01 | <.01 | | |
| 20:00-21:00 | | - | - | <.004 | .011 | <.01 | <.01 | | |
| 21:00-22:00 | 2 | .007 | .016 | .008 | .014 | <.01 | <.01 | 350° | |
| 22:00-23:00 | | .016* | .022 | .024* | .036 | <.01 | <.01 | 355° | |
| 23:00-24:00 | | .012* | .022 | .015* | .031 | <.01 | <.01 | 350° | |
| June 15 | | | | | | | | | |
| 00:00-01:00 | | .012* | .025 | .022* | .058 | <.01 | <.01 | 350° | |
| 01:00-02:00 | | .004 | .006 | <.004 | .007 | <.01 | <.01 | 355° | |
| 02:00-03:00 | | .003 | .006 | .006 | .018 | <.01 | <.01 | 360° | |
| 03:00-04:00 | | .006 | .010 | .014* | .062 | <.01 | <.01 | 360° | |
| 04:00-05:00 | | .002 | .002 | <.004 | <.004 | <.01 | <.01 | 345° | |
| 05:00-06:00 | | .004 | .009 | .004 | .011 | <.01 | <.01 | 325° | |
| 06:00-07:00 | | .005 | .005 | <.004 | <.004 | <.01 | <.01 | 335° | |
| 07:00-08:00 | | .007 | .014 | .007 | .024 | <.01 | <.01 | 315° | -sunny, clear, intermittent |
| 08:00-09:00 | | .005 | .011 | .008 | .024 | <.01 | <.01 | 335° | odours still present |
| 09:00-10:00 | | .007 | .010 | .010 | .040 | <.01 | .012 | 360° | |
| 10:00-11:00 | | .006 | .009 | .005 | .016 | <.01 | <.01 | 350° | -faint odour |
| 11:00-12:00 | | .007 | .011 | cal. | cal. | cal. | cal. | 345° | |
| 12:00-13:00 | | .005 | .009 | .004 | .020 | <.01 | <.01 | 010° | |
| 13:00-14:00 | | .004 | .005 | <.004 | <.004 | <.01 | <.01 | 350° | |
| 14:00-15:00 | | .005 | .005 | <.004 | .009 | <.01 | <.01 | 335° | |
| 15:00-16:00 | | .005 | .007 | <.004 | <.004 | <.01 | <.01 | 350° | |
| 16:00-17:00 | 1 | - | - | - | - | - | - | - | -move to site No. 1 |
| 17:00-18:00 | | .004 | .005 | <.004 | .007 | <.01 | <.01 | 275° | -slight odour present |
| 18:00-19:00 | | .003 | .004 | .004 | .011 | <.01 | <.01 | 290° | |
| 19:00-20:00 | | .004 | .005 | <.004 | .007 | <.01 | <.01 | 290° | |
| 20:00-21:00 | | .006 | .013 | <.004 | .007 | <.01 | <.01 | 275° | |
| 21:00-22:00 | | .003 | .006 | .007 | .018 | <.01 | <.01 | 270° | |
| 22:00-23:00 | | .004 | .004 | .004 | .008 | <.01 | <.01 | 240° | |
| 23:00-24:00 | | .004 | .008 | <.004 | <.004 | <.01 | <.01 | 230° | |
| June 16 | | | | | | | | | |
| 00:00-01:00 | | .008 | .010 | <.004 | .005 | <.01 | <.01 | 205° | |
| 01:00-02:00 | | .008 | .010 | <.004 | .007 | <.01 | <.01 | 205° | |
| 02:00-03:00 | | .004 | .007 | <.004 | <.004 | <.01 | <.01 | 205° | |
| 03:00-04:00 | | .003 | .007 | <.004 | <.004 | <.01 | <.01 | 225° | |
| 04:00-05:00 | | .003 | .004 | <.004 | <.004 | <.01 | <.01 | 220° | |
| 05:00-06:00 | | .003 | .004 | <.004 | <.004 | <.01 | <.01 | 220° | |
| 06:00-07:00 | | .006 | .007 | <.004 | <.004 | <.01 | <.01 | 220° | |
| 07:00-08:00 | | .005 | .007 | <.004 | <.004 | <.01 | <.01 | 220° | |
| 08:00-09:00 | | .004 | .005 | cal. | cal. | cal. | cal. | 225° | |
| 09:00-10:00 | | .002 | .004 | cal. | cal. | cal. | cal. | 240° | |
| 10:00-11:00 | | .002 | .002 | cal. | cal. | cal. | cal. | 230° | |
| 11:00-12:00 | | .002 | .004 | cal. | cal. | cal. | cal. | 240° | |
| 12:00-13:00 | | .002 | .002 | cal. | cal. | cal. | cal. | - | |
| 13:00-14:00 | | .002 | .002 | <.004 | <.004 | <.01 | <.01 | 235° | |
| 14:00-15:00 | | .002 | .002 | <.004 | <.004 | <.01 | <.01 | | |
| 15:00-16:00 | 3 | - | - | - | - | - | - | - | -moving to site #3 |
| 16:00-17:00 | | - | - | - | - | - | - | - | -at site #3 there was an |
| 17:00-18:00 | | .002 | .002 | <.004 | <.004 | <.01 | <.01 | 250° | occasional odour (very |
| 18:00-19:00 | | .002 | .002 | <.004 | <.004 | <.01 | <.01 | 265° | slight) obviously below |
| 19:00-20:00 | | - | - | <.004 | <.004 | <.01 | <.01 | 235° | instrument threshold. |
| 20:00-21:00 | | - | - | <.004 | <.004 | <.01 | <.01 | | -on board met. data not |
| 21:00-22:00 | | | | <.004 | <.004 | <.01 | <.01 | (140°) | available, however, infor |
| 22:00-23:00 | | | | <.004 | <.004 | <.01 | <.01 | (130°) | mation obtained from The |
| 23:00-24:00 | | | | <.004 | <.004 | <.01 | <.01 | (150°) | Pas airport aviation |
| June 17 | 3 | | | | | | | | weather office confirmed |
| 00:00-01:00 | | | | <.004 | <.004 | <.01 | <.01 | (160°) | winds between 150° - |
| 01:00-02:00 | | | | <.004 | <.004 | <.01 | <.01 | (160°) | 210° (True North). |
| 02:00-03:00 | | | | <.004 | <.004 | <.01 | <.01 | - | |
| 03:00-04:00 | | | | <.004 | <.004 | <.01 | <.01 | (160°) | |
| 04:00-05:00 | | | | <.004 | <.004 | <.01 | <.01 | (170°) | |
| 05:00-06:00 | | | | <.004 | <.004 | <.01 | <.01 | (190°) | |
| 06:00-07:00 | | | | <.004 | <.004 | <.01 | <.01 | - | |
| 07:00-08:00 | | | | <.004 | <.004 | <.01 | <.01 | (170°) | |
| 08:00-09:00 | | | | <.004 | <.004 | <.01 | <.01 | (170°) | |

* Levels exceed guideline values

TABLE 3. Survey Data Summary (a)

| Site No. | Times and Date | No of Hours | Average Conc.(ppm) | | |
|---|---|---|---|---|---|
| | | | $H_2S$ | TRS | $SO_2$ |
| 2 | 21:00 14/6/83 - 16:00 15/6/83 | 19 | .006 | | |
| | | 18 | | .007 | <.01 |
| 1 | 17:00 15/6/83 - 15:00 16/6/83 | 22 | .004 | | |
| | | 17 | | <.004 | <.01 |
| 3 | 17:00 16/6/83 - 09:00 17.6/83 | 16 | | <.004 | <.01 |

TABLE 4. Survey Data Summary (b)

| | $H_2S$ | TRS | $SO_2$ |
|---|---|---|---|
| Total No. of Monitoring Hours | 48 | 60 | 60 |
| Downwind Monitoring (hrs) | 24 | 31 | 31 |
| % of Total | 50% | 51.7% | 51.7% |
| Average Concentration (ppm) | .0059 | .0061 | trace |
| Background (not downwind) Monitoring (hrs) | 24 | 29 | 29 |
| % of Total | 50% | 48.3% | 48.3% |
| Average Concentration (ppm) | .004 | <.004 | trace |
| Total 1-hr Exceedances (MAQO) | 3 | 5 | 0 |
| Downwind Exceedances | 3 | 5 | - |
| % Of Total | 100% | 100% | - |

## 6. DISCUSSION OF RESULTS

Upon arriving in The Pas, setting up the equipment, and performing multipoint calibrations on the analyzers, ideal conditions were found for monitoring on the south side of the Saskatchewan River. Tuesday afternoon (June 14) the sky was almost completely overcast and there was some rain, with unseasonally cool temperatures and a fairly strong (approx. 20-30 km/hr) north wind. Weather conditions were such that emissions from the stacks at the Manfor mill (plant was visible from stations 1 and 2) were held fairly close to the ground and impinged on the areas downwind with regular frequency. In the vicinity of station AM-1 (see Appendix A for site description), there was a visible haze at ground level. It was under these conditions that the highest readings of $H_2S$ and TRS occurred and were accompanied with very strong odours. Under these conditions, ground level readings exceeded the $H_2S$ guideline on three occasions (June 14, 2300 h - .016 ppm; 2400 h - .012 ppm and June 15, 0100 h - .012 ppm). Applying the $H_2S$ guideline to TRS levels the following five exceedances were noted (June 14, 1200 h - .012 ppm; 2300 h - .024 ppm; 2400 h - .015 ppm; June 15, 0100 h - .022 ppm; 0400 h - 0.014 ppm). Only minute traces of $SO_2$ were detected and the air quality objective for sulphur dioxide was never exceeded.

People who live in the area of stations AM-1 and AM-2 (along Provincial Trunk Road 285/Rahl's Island Road) reported that while incidents or episodes similar to those experienced June 14 and 15 south of the mill (downwind) are infrequent, they are not uncommon.

By Thursday, June 16 the meteorological conditions had changed considerably from those observed earlier in the week. Wind direction had swung counter-clockwise about $100^{\circ}$ southward and winds predominated from a south westerly direction. The accompanying velocity had decreased to about 10 km/hr, skies were clear and sunny and generally the plume from Manfor was seen to rise and disperse at

altitudes several hundred feet above the ground to the north-east of the mill. Unfortunately this area is inaccessible by road. The closest access is off the Cormorant Road (Provincial Trunk #287) east of The Pas airport, an area almost 20 km from the plant. A visit there (by car) to an access road from Road #287 to Orok revealed only very faint and infrequent odours. It was decided that in all likelihood monitoring in this vicinity would prove fruitless. This conclusion was substantiated by the subsequent monitoring at site number AM-3.

Thursday evening the winds were quite light (velocity) and were from the south-southwest. Site number AM-3 was chosen downwind from the plant on Trunk Road 287 about 4.5 km east of the junction with Highway 10 and about 12 km from the Manfor Mill. The mill was not visible from this site but there were occasional faint odours of suspected sulphides present. If these compounds were present, they were at concentrations below the threshold sensitivity of the ambient air analyzers, demonstrated by the fact that continuous monitoring at this site undertaken Thursday and Friday did not indicate the presence of either $H_2S$ (as measured by the Toxic Gas Monitor) or total reduced sulphur (TRS) compounds (reported as $H_2S$). Information obtained from the aviation weather office at The Pas airport confirmed that monitoring was at a downwind venue from the Manfor Paper Mill at the time that odours were detected.

A downwind location was determined by comparing wind directions to the compass bearing of the source with respect to the monitoring site. This bearing, plus or minus $20^{\circ}$ yields the wind direction range within which the receptor site was considered to be downwind of the source. This is of course a generalization and factors such as, the distance of the receptor from the source, wind velocity, and the variability of the horizontal component of wind will influence this range. For this study, the following ranges were used:

i) Site AM-1 is downwind of the Manfor mill when the wind direction (hourly average) ranged between 300° to 340° (i.e. 320°±20°)

ii) Site AM-2 is downwind of the Manfor mill when the wind direction ranged between 330° to 010°

iii) Site AM-3 is downwind of the Manfor mill when the wind direction ranged between 170° to 210°.

As a result of the fact that monitoring was conducted at individual monitoring sites for less than 24 hours, assessment of the data with respect to the 24-hour criteria for $H_2S$ is of an estimative nature. It is felt that the average after 16 or more hours can be extrapolated to 24 hours. Thus, 24 hour concentrations can be estimated for sites AM-1, AM-2 and AM-3 for the periods noted. Due to variation in meteorological conditions not all of this monitoring was conducted downwind of the source.

A comparison of the Manitoba Air Quality Objectives and Guidelines with monitored downwind conditions for the two averaging time periods follows.

One-hour

1) Number of cardinal hours (downwind) when the 1-hour Maximum Acceptable Level (MAL) was exceeded for hydrogen sulphide was 3 of 24 (12.5%).

2) Number of cardinal hours (downwind) when the 1-hour MAL for TRS (reported as $H_2S$) exceeded the criteria for hydrogen sulphide was 5 of 31 (16.1%).

3) Only minute traces of $SO_2$ were detected and the criteria for sulphur dioxide was never exceeded.

24-hour

1) Monitoring for 19 hours in the vicinity of site AM-2 indicated elevated concentrations of $H_2S$, of sufficient

magnitude to produce (in all probability) a 24-hour level in excess of the MAL.

2) Concurrent monitoring for 18 hours indicated elevated concentrations of total reduced sulphur compounds (reported as $H_2S$), of sufficient magnitude to produce a 24-hour TWA in excess of the level stipulated in the MAQG for $H_2S$.

3) For most of the monitoring, $SO_2$ levels were below the detection threshold of the analyzer (.01 ppm). There was no indication that, under conditions similar to those experienced during this study, the criteria for 24-hour average concentration of $SO_2$ would be exceeded.

Ambient air levels of TRS compounds (measured as $H_2S$) at the stationary monitoring site in the townsite of The Pas over the last ten years are summarized in Table No. 5. Levels above the Provincial guidelines for $H_2S$ have been observed, on occasion. The frequency of occurrences is influenced by wind direction, wind velocity and emission levels from the plant. However, data from this long term monitoring appears to be consistent with observations made in this short-term study.

Referring to the episodal nature of the elevated levels of TRS compounds measured on Tuesday and Wednesday, June 14 and 15 the following observation should be noted. Taking, for example, the five hour period from 21:00 (14/7/83) to 02:00 (15/7/83), we find that in considering hourly averages, for the concentration of TRS compounds (reported as $H_2S$), using stricly cardinal hours (e.g. 21:00-22:00, 22:00-23:00 etc.) within the 5 hour period, there were three hours in which the average concentration exceeded the guideline or there were 60% exceedances. However, taking the same time (21:00-02:00) and calculating a moving average with a 5 minute offset (e.g. 21:00-22:00, 21:05-22:05, 21:10-22:10, etc. up to 00.50-01:50, 00:55-01:55 and 01:00-02:00) we find that, of a total of 49 one hour periods, 38

TABLE 5. Data Summary from Impingement Station #7111, The Pas.
Total Reduced Sulphur Compounds (as $H_2S$) 1973-1982

| Year | No. of Months Available | % of Data Available | Maximum Data Values (ppm) | | No. of Samples Above, M.A.L. | |
|---|---|---|---|---|---|---|
| | | | 1-HR | 24-HR | 1-HR | 24-HR |
| 1973 | 2 | 15.4 | .018 | .002 | 0 | 0 |
| 1974 | 0 | 23.7 | .025 | .004 | 28 | 1 |
| 1975 | 1 | 16.0 | .008 | .002 | 0 | 0 |
| 1976 | 1 | 34.8 | .046 | .006 | 1 | 60 |
| 1977 | 0 | 31.3 | .010 | .003 | 0 | 16 |
| 1978 | 2 | 46.0 | .024 | .003 | 4 | 0 |
| 1979 | 0 | 21.8 | .021 | .003 | 2 | 0 |
| 1980 | 12 | 84.1 | .035 | .002 | 6 | 0 |
| 1981 | 8 | 65.9 | .027 | .004 | 16 | 0 |
| 1982 | 11 | 67.1 | .016 | .006 | 15 | 5 |

Note: Prior to January 1978 the 1-hour objective for $H_2S$ was set at .020 ppm instead of the current level of .011 ppm. The 24-hour criteria was also revised from .002 ppm (pre-1978) to .004 (current).

exceed the guideline or there were 77.6% exceedances. Thus, it can be seen that with the increased resolution of a 1 hour moving average, percentage exceedances increase. The increase in this case is 17.6% which is certainly a significant amount. Since the guideline is for any one hour average, then it would seem that the 77.6% figure is a more precise representation of the probability that, under conditions similar to those experienced during this particular five hours, a receptor, during any consecutive 60 minute period will be exposed to levels of total reduced sulphur compounds that exceed the stated guideline.

There were no audible sounds from the plant at Site AM-3, consequently no sound level measurements were obtained. Results from sound monitoring at other sites are recorded on the Site Inspection Forms in Appendix B. A review of the measurements obtained, reveal that noise levels, monitored in the vicinity of the Manitoba Forestry Resources, do not constitute violations of existing guidelines. Noise levels from the Manfor operations did not represent a residential nuisance at the time of monitoring.

## 7. CONCLUSIONS

In reviewing the production information (contained in Table 6), it appears that during the period of monitoring, production levels at the Manfor mill were about normal and thus emission levels are representative of day-to-day operations. Therefore, regarding air quality measurements conducted during this study, it can be concluded:

1. Under meteorological conditions similar to those early in the week of June 13-17, Manitoba Air Quality $H_2S$ Guidelines for 1-hour and 24-hour periods could be exceeded in The Pas area by both $H_2S$ and the broader spectrum of total reduced sulphur compounds (reported as $H_2S$). This conclusion is substantiated by the data obtained from the stationary monitor in the town of The Pas, which

reveals a history of incidents, over the previous 10 years, where the guidelines have been exceeded . At greater distances from the source it seems that emissions are sufficiently dispersed to maintain ambient concentrations within guideline levels, although detectable odours may still be present.

2. There was no indication, during this study, of elevated levels of sulphur dioxide. Ambient concentrations were consistently found to be well below the guideline levels. In fact, only traces of $SO_2$ were found and levels were, for the most part, beneath the detection threshold of the monitoring instrument.
3. Regarding sound measurements, it would seem that the operations at Hanford, do not pose a residential nuisance with respect to noise in excess of existing guidelines.

TABLE 6. 1983 Hanford Daily Production Summary (Prepared 83/06/21)

| Period No. 10 | Week 2 From 1983-06-12 to 1983-06-18 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Sun. | Mon. | Tue. | Wed. | Thu. | Fri. | Sat. | Week | Period | Year |
| Net-Production (Tons/Day) | 382 | 359 | 374 | 406 | 313 | 532 | 522 | 2888 | 5811 | 82761 |
| Operating Days | | | | | | | | 7.00 | 14.00 | 214.37 |
| Ave. Daily Tons | | | | | | | | 413 | 415 | 386 |

**REFERENCES**

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3. Air Standards and Studies Section, Environmental Management Division (Manitoba), revised March 1982 Manitoba Ambient Air Quality - Data Summaries, 1970-1982.

4. Department of Mines, Resources & Environmental Management, Environmental Protection Laboratory, 1974, Churchill Forest Industries, The Pas, Manitoba, Air Pollution Assessment Report (Prepared by M. V. Lysyk).

5. Particulate sampling of power boiler #1 and the recovery boiler at Manitoba Forestry Resources Ltd., The Pas, Manitoba, Air Pollution Control Section, Environmental Management Division (Manitoba) 1983.

6. Recommended air quality objective for hydrogen sulphide; Federal Provincial Committee on Air Pollution minutes, circa 1974; unpublished.

7. Georgii, H. W. 1970. Journal of Geophysical Resources, Volume 75 2365-2371 as cited in "Review of national ambient air quality objectives for sulphur dioxide". 1982, Subcommittee on National air quality objectives.

8. Personal communication, Philips Electronics.

9. Map for this study obtained from:
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# APPENDICES

Appendix A

Ambient Air Monitoring Sites (designated AM on map)

Site No. AM-1 - Map grid reference 561679 (Universal Transverse Mercator Grid UTMG)

Description a) South side of Saskatchewan River

b) South-southeast of Manfor Paper Mill (Manfor bearing 320° w.r.t. AM-1)

c) 3.0 km east of Dump Road

d) South side of Manitoba Trunk Road 285

e) Approximately 2.9 km from Manfor Paper Mill

Site No. AM-2 - Map grid reference 547675 (UTMG)

Description a) South side of Saskatchewan River

b) Almost due south of Manfor Paper Mill (Manfor bearing 350° w.r.t AM-2)

c) 1.4 km east of Dump Road

d) Southside of Manitoba Trunk Road 285

e) Almost directly across the river from Manfor's Pump House

f) Approximately 2.7 km from the Paper Mill

Site No. AM-3 - Map grid reference 568822 (UTMG)

Description a) North side of Manitoba Trunk Road 287

b) Approximately 12 m from highway centre-line

c) 12.25 km north-northeast of Manfor Paper Mill

d) 4.5 km east of Junction Hwy 10 and Road 287 (Manfor bearing 190° w.r.t. AM-3)

cont'd

Appendix A continued

Sound Monitoring (designated as S on map)

Site No. S-1 - Same as ambient air monitoring site AM2

Site No. S-2 - Map grid reference 525703 (UTMG)

Description a) Junction of Manitoba Trunk 289 (map)/610 (actual signage) and R.R. tracks.

b) Approximately 1.5 km west of Manfor Paper Mill

Site No. S-2 - Map grid reference 547679 (UTMG)

Description a) Westside of Manfor pump house

b) North side of Saskatchewan River

c) Approximately 2.25 km south of Manfor Paper Mill

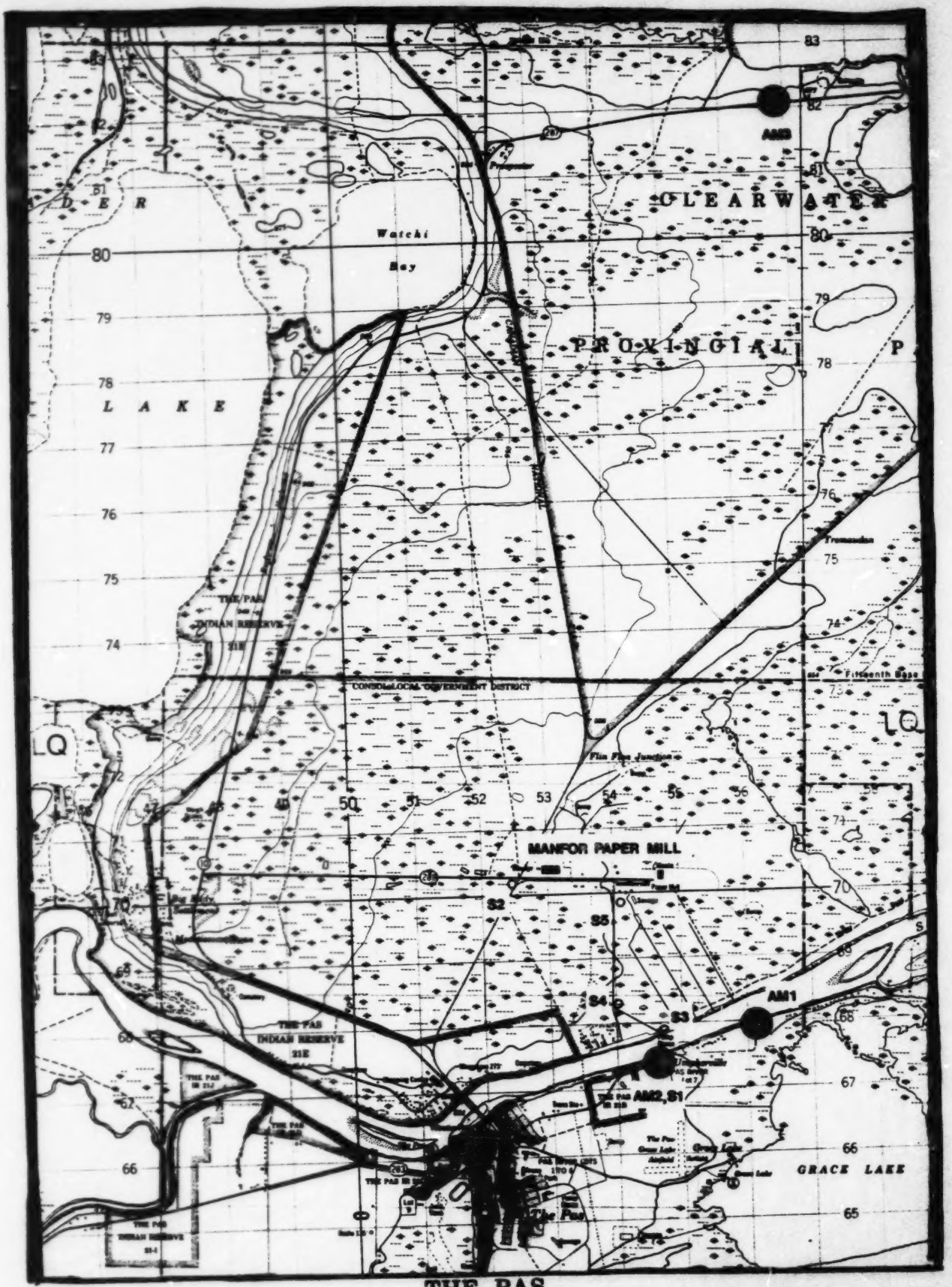
Site No. S-4 - Map grid reference 539683 (UTMG)

Description a) Junction of Pumphouse Road and Umperville Road

b) Approximately 1.9 km south of Manfor Paper Mill

Site No S-5 - Map grid reference 540710 (UTMG)

Description a) Immediately south-west of Manfor Paper Mill (approx. 200 m away), on Umperville Road




# THE PAS

## MANITOBA

WEST OF PRINCIPAL MERIDIAN - OUEST DU MÉRIDIEN PRINCIPAL

Scale 1:50 000 Échelle

● Ambient Air Monitoring Sites (AM)

○ Sound Monitoring Sites (S)

# APPENDIX B

MANITOBA

Environmental Management Division
Box 7, Building 2
139 Tuxedo Avenue
Winnipeg, Canada
R3C 0V8

FILE 1824.0

ES 121(b)

## ENVIRONMENTAL MANAGEMENT DIVISION
## SITE INSPECTION FORM

| | |
|---|---|
| SUBJECT | Monitoring of Sound Levels in the vicinity of the Manitoba Forestry Products Mill in The Pas, Manitoba. |
| DATE OF INSPECTION | June 15, 1983 S-1 |
| CONTACTS: | NAME POSITION |
| | NAME POSITION |

REMARKS

For a description of site S-1 (location) see Monitoring Sites section of the attached report.

Time: 10:15 - 10:30

Weather: Brisk winds approximately 15-20 km/hr. from N.W.

Calibration: O.K. (94dBA)

Observations: Wind noise about 58 dBA gusts to 69dBA

Background 44-46 dBA

Steady plant noise barely audible, impossible to determine any elevated noise levels as a result of mill operations.

MG-8626(a)

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Winnipeg, Canada
R3C 0V8

FILE 1834.0

ES 121(b)

## ENVIRONMENTAL MANAGEMENT DIVISION
## SITE INSPECTION FORM

SUBJECT: Monitoring of Sound Levels in the vicinity of the Manitoba Forestry Products Mill in The Pas, Manitoba

DATE OF INSPECTION: June 15, 1983 S-2

CONTACTS: NAME POSITION

NAME POSITION

REMARKS

For a description of site S-2 (location) see Monitoring Sites section of the attached report.

Time: 14:24 - 14:40

Weather: Winds N. N.W., 15-20 km/hr. gusting.

Calibration: O.K. 94.4 dBA.

Observations: Background wind gusting to maximum 60 dBA but steady at about 54 dBA.

Wind occasionally dropped to less than 50 dBA.

Noted an intermittent sound from mill occurring about every 10 min. and lasting for between 30 sec. and 1 min.

Sounded like a high pressure venting similar to a low frequency horn signal. This signal was measured at approximately 48 dBA in the absence of wind noise about 1-2 dBA above background.

MG-8828(a)

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Winnipeg, Canada
R3C 0V8

FILE 1834.0

88 121(b)

**ENVIRONMENTAL MANAGEMENT DIVISION**
**SITE INSPECTION FORM**

| | |
|---|---|
| SUBJECT | Monitoring of Sound Levels in the vicinity of the Manitoba Forestry Products Mill in The Pas, Manitoba. |
| DATE OF INSPECTION | June 15, 1983 S-3 |
| CONTACTS: | NAME POSITION |
| | NAME POSITION |

REMARKS

For a description of site S-3 (location) see Monitoring Sites section of the attached report.

Time: 15:15 - 15:30.

Weather: Winds N. N.W., 15-20 km/hr. gusting

Calibration: O.K. 94.0 dBA

Observations: Levels varied between 42 dBA (background with no wind) to 54 dBA (wind gusts and possibly plant noise).

Noise from the mill was estimated at about 2 dBA above background.

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ES 121(b)

**ENVIRONMENTAL MANAGEMENT DIVISION**
**SITE INSPECTION FORM**

| | |
|---|---|
| SUBJECT | Monitoring of Sound Levels in the vicinity of the Manitoba Forestry Products Mill in The Pas, Manitoba |
| DATE OF INSPECTION | June 16, 1983 — S-1 |
| CONTACTS: | NAME — POSITION |
| | NAME — POSITION |

| REMARKS |
|---|
| For a description of site S-1 (location) see Monitoring Sites section of the attached report. |
| Time: 1201 - 12:30 |
| Weather: Winds W. S.W. 10 km/hr. light. |
| Calibration: O.K. 94:0 dBA |
| Observations: Baseline level (background) at 42 dBA (with some process noise from the Mill and very light wind). |
| Steam venting at 12:08 for about 30 sec. This signal (horn sound) was about 2 dBA over background. Wind gusts occasionally to 50 dBA. |
| At 12:11 a second type of venting was heard. This sounded like rushing water and is like an amplified type of the normal, constant process noise. |
| This sound was constant at about 47-49 dBA (approximately 5 dBA over normal) and lasted about 1 min. |
| 12:16 - An occurrence of the first type of venting (horn sound) lasted for about 1 min. at around 46 dBA. |
| |
| |
| |

MG-0529(b)

MANITOBA

Environmental Management Division
Box 7, Building 2
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Winnipeg, Canada
R3C 0V8

FILE 1834.0

BS 1216(a)

## ENVIRONMENTAL MANAGEMENT DIVISION
## SITE INSPECTION FORM

SUBJECT: Monitoring of Sound Levels in the vicinity of the Manitoba Forestry Products Mill in The Pas, Manitoba.

DATE OF INSPECTION: June 16, 1983

CONTACTS: NAME — POSITION: S-4

NAME — POSITION

REMARKS:

For a description of site S-4 (location) see Monitoring Sites section of the attached report.

Time: 14:00 - 14:30

Weather: Winds W. S.W. <10 km/hr. light

Calibration: O.K. 94.0 dBA

Observations: Baseline level (background) at 38 dBA

Steam venting at 14:07, type 1 (horn sound) level at 40 dBA about 2 dBA over baseline duration about 1 min.

14:16 steam venting type 1 (horn sound) level at 47 dBA about 4 over baseline (now approximately 44 dBA) duration about 1 min.

14:27 - Type 1 (horn sound) steam venting - duration 56 sec. at 46 dBA about 4 dBA over baseline.

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FILE 1824.0

ES 121(b)

**ENVIRONMENTAL MANAGEMENT DIVISION**
**SITE INSPECTION FORM**

SUBJECT

Monitoring of Sound Levels in the vicinity of the Manitoba Forestry Products Mill in The Pas, Manitoba.

DATE OF INSPECTION

June 16, 1983 S-5

CONTACTS: NAME POSITION

NAME POSITION

REMARKS

For a description of site S-5 (location) see Monitoring Sites section of attached report.

Time: 14:35 - 15:00

Weather: Winds W. S.W. 10 km/hr. light

Calibration: O.O. 94.0 dBA

Observations: Baseline level (background) at 60 dBA - this includes constant process noise from the mill.

14:36 - Type 1 (horn sound) at about 72 dBA. approximately 12 over baseline - duration about 1 min.

14:47 - Type 1 (horn sound) at about 70 dBA approximately 10 over baseline (60 dBA) duration 55 sec.

POOR

QUALITY

ORIGINAL